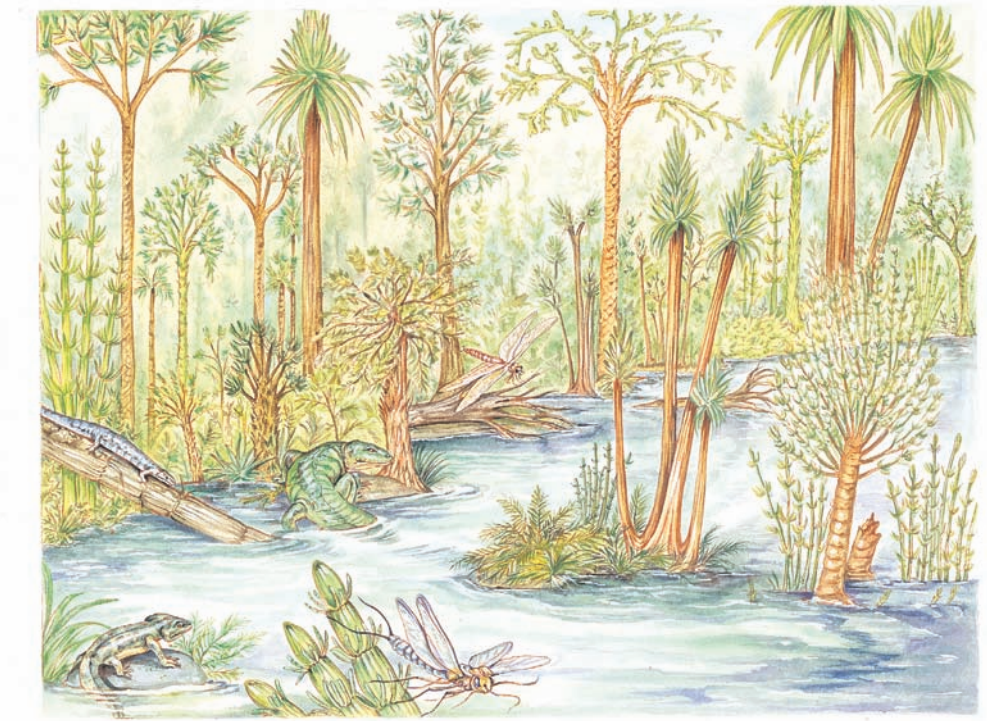
CHAPTER 8

Fossil Fuels

Getting Ready...

- List the fossil fuels that you know of.
- What do you already know about how fossil fuels were formed?
- What are the risks of burning fossil fuels?
- How is the fossil fuel industry important to Alberta?



Science Log

List five ways in which you depend on fossil fuels. For each, note how this use of fossil fuels might affect the environment.

Imagine what Alberta must have been like millions of years ago. Temperatures were much warmer. Lush green vegetation covered much of the land. The rest was covered by oceans.

Abundant life filled the ocean and forests. When organisms died, their remains accumulated in stagnant swamps. Over centuries, seas rose or land sank, and the swamps were covered.

Solar energy captured by those ancient plants and animals has been transformed and is still here for us to use. How did these incredible transformations take place?

Today our society relies heavily on the remains of ancient forests and long-dead marine life. From their remains, we produce gasoline and diesel to fuel motor vehicles. We transform other energy stored as coal and natural gas into electric energy.

In this chapter you will learn about the formation of fossil fuels. You will examine their extraction and refining, and you will investigate their burning. Finally, you will analyze the impact that burning fossil fuels has on the environment.

What You Will Learn

In this chapter you will learn:

- when fossil fuels were formed
- how fossil fuels are extracted and refined
- how combustion of fossil fuels and cellular respiration are related
- about the risks and benefits associated with the use of fossil fuels

Why It Is Important

- Energy from fossil fuels powers vehicles for businesses and individuals. For most of us, this fuel heats and lights our homes and cooks our food. By learning about the positive and negative aspects of fossil fuels, you will be able to make better judgements about how you use them.

Skills You Will Use

In this chapter you will:

- model what happens to oil, water, and gas under the Earth's surface
- model the distillation of crude oil
- investigate the combustion of fossil fuels
- analyze the impact of fossil fuel technologies on the environment

Starting Point ACTIVITY

Oil and Water

Not long ago, you could not buy bottled drinking water in Canada. How much does it cost today? How much is oil worth? Which of these liquids is the most important to *your* life?

What You Need

local and regional newspapers

weekly advertisements

What to Do

1. Use newspapers, advertisements, a web search, or other sources of information to determine the following:

   (a) What is the price, in your area, for one litre of motor oil?
   (b) What is the price, in your area, for one litre of bottled drinking water?
   (c) At our current rate of use, how long do scientists believe our global oil reserves will last? Are we using more or less oil than 20 years ago?
   (d) Is Canada in danger of facing water supply shortages? Should we be building pipelines to transport water to the United States? Should we ship it to other countries? Why or why not?

What Did You Discover?

1. Do the analysis provided by your teacher.

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2
Use the Internet to collect information on global oil and fresh-water reserves. Go to the above web site, then to Internet Connects, Unit B, Chapter 8, and then to Oil and Water Reserves.

8.1 What Are Fossil Fuels?

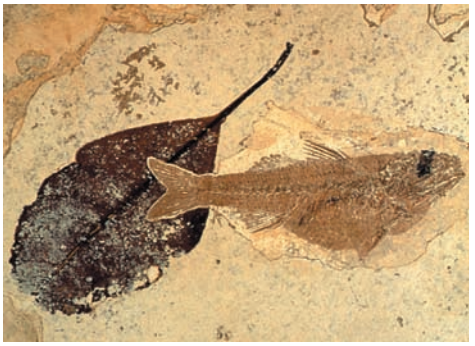


Figure 8.1 This fish lived millions of years ago. You can still see its shape in this rock. Learning how this shape stayed in the rock will also tell you the story of fossil fuels.

When you hear the word "fossil," you may think of the skeleton of a fish embedded in rock, such as the one shown in Figure 8.1. Or you may think of shell-like impressions in rock. With this knowledge you are well on your way to understanding **fossil fuels**.

Coal, crude oil, and natural gas are commonly used fossil fuels. Like the fossils you can see in rock, they were once living organisms. Instead of being converted into fossils, the organic material from these plants and animals piled up on the bottom of a swamp, lake, or ocean. It was then covered with many layers of sediment.

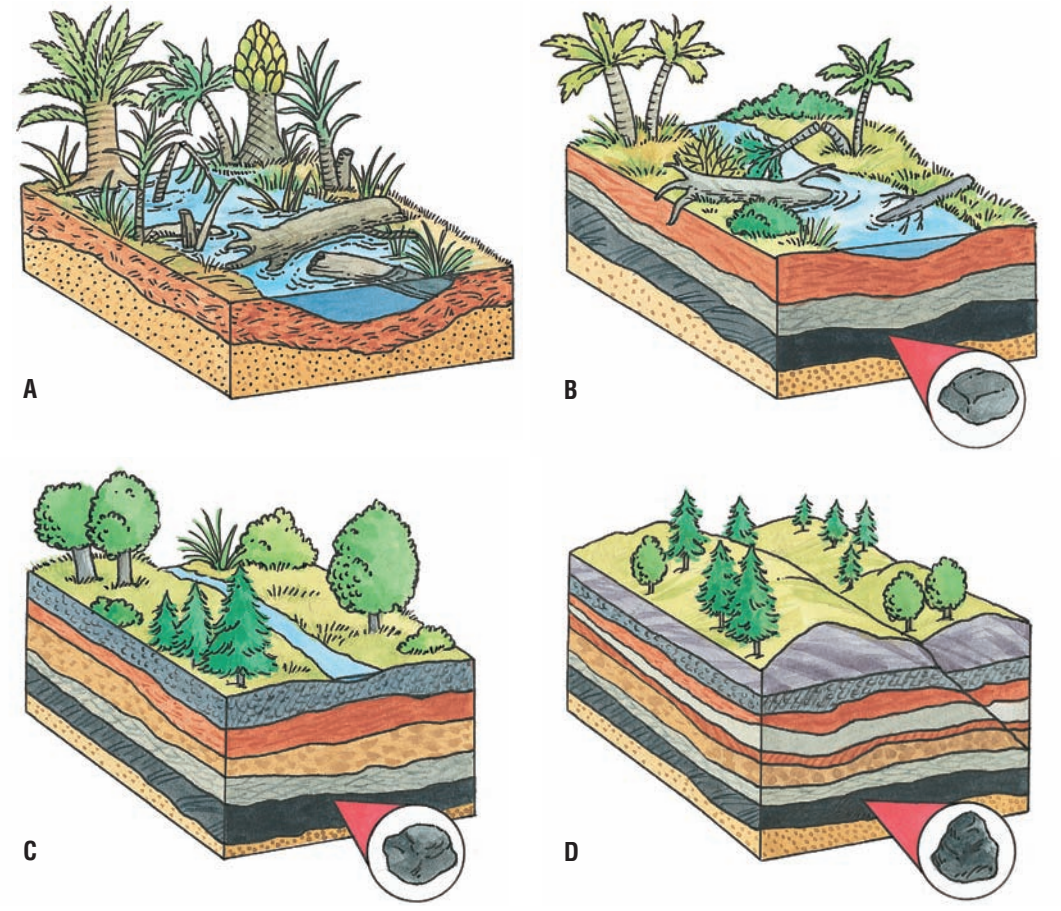


Figure 8.2 Fossil fuels take a long time to develop. These visuals show how different types of coal developed. Crude oil was formed in a similar way.

A Coal was formed from the remains of ancient swamp vegetation that lived about 300 million years ago.

B The plants died and fell into the swamp. Their organic material was covered by layers of sediment. There was no oxygen in these layers, so the plant material could not decompose. Hydrogen and carbon from the organic material were locked together underground. Eventually, they formed a solid layer of lignite, which is a soft coal.

C More layers of sediment piled on top of the lignite and compressed it even further. Because the layers were so deep and there was so much pressure, temperatures increased. The heat and pressure compressed the lignite into a harder coal, called bituminous coal.

D In some areas, layers of bituminous coal were compressed and heated even further. This produced an even harder coal called anthracite.

The layers of sediment were often several kilometres thick. Heat and pressure changed the decaying organic matter into **coal**, oil, and natural gas. Because they formed from plants and animals that lived long ago, we call these three materials fossil fuels. Examine Figure 8.2 and identify the steps that transformed dead organic material into a fossil fuel such as coal.

READING Check

List the steps in the formation of coal.

The Use of Coal, Oil, and Natural Gas

Coal has been used as a fuel for at least 3000 years. It is abundant in most parts of the world, but was used only a little until the invention of the steam engine. For more than 100 years, steam engines were used to power factories and move people and goods.

Coal was and still is popular because it is cheap, easy to mine, and easy to transport. That is why it provided almost all of the thermal energy for the steam engines that made our country grow — and why it is still popular today for some industrial uses.

Oil and gas have not been used for as long a period as coal. Ancient eternal fires burning in the Iraq area were reported by travellers 1900 years ago. These were probably the result of **natural gas** escaping from cracks in the ground and being ignited by lightning.

Natural gas is difficult and dangerous to control and transport. That is why its potential energy has only been used in recent years.

Crude oil, also called **petroleum**, is found as a liquid. Crude oil is extracted by drilling a hole into Earth's crust. In some cases, the oil is under pressure and will come out of the hole on its own. In other locations, it has to be pumped to the surface. Investigation 8–A will give you an opportunity to observe the behaviour of these two fuels.

DidYouKnow?

There are three types of coal found in Alberta. Lignite is a soft brown or black coal found in southeastern Alberta. Sub-bituminous coal is softer than bituminous and contains more moisture. Alberta is the only province in Canada where sub-bituminous coal is mined. It is used to generate most of the province's electricity. Bituminous coal is also found in many areas of the province.

Figure 8.3 Tiny diamonds fixed in the tip of drills cut holes through rock to oil and gas reservoirs.

DidYouKnow?

In 1885, Robert Bunsen invented a burner that mixed air with natural gas. The Bunsen burner showed how gas could be used to provide heat for cooking and warming buildings.

READING Check

How was coal used 100 years ago?

Off the Wall

Aboriginal people in southern Alberta were the first to notice a thick black liquid ooze to the surface of Earth. They used this oil for healing.

Key Terms

fossil fuels
coal
natural gas
crude oil
petroleum

Check Your Understanding

1. List three fossil fuels.
2. Sketch and label four steps in the formation of coal.

8.2 Extracting Coal and Oil

Since the late 1800s, the coal industry has been an important part of Alberta's history.

- For more than a century, coal was the main energy source for the Canadian Pacific Railway and most of Alberta's industries.
- Chapter 6 discussed how most of Alberta's electric energy is produced in coal-burning thermal plants.
- Most of the iron and steel used in Alberta's industries has been produced in other parts of the world. Many of these other areas use the potential energy stored in coal from Alberta to produce iron and steel.

READING Check

List two ways Alberta coal is used.

Mining Coal

How is coal mined for all these purposes? The coal formed during the process shown in Figure 8.2 on page 136 developed into flat layers. Depending on the area, these layers occur as thick beds or long seams. Over many millions of years, these beds and seams of rock were folded and deformed. In order to mine coal, miners look for a seam or bed of coal.

Deposits close to the surface of Earth are often quarried in much the same way as sand and gravel are quarried. Coal quarries are called open-pit mines.

Figure 8.4 Coal discoveries in western Canada aided and encouraged settlement by Europeans.

Deposits that are deep below Earth's surface are dug using networks of underground rooms and tunnels. Machinery cuts into the coal, and conveyor belts lift it to the surface.

Study Figure 8.5 to see how mining companies reclaim the damaged land after the coal runs out.

READING Check

Explain the difference between an underground and an open-pit mine.

Figure 8.5 An open-pit mine devastates the landscape. Trees and soil are removed to retrieve coal. Environmentally conscious coal companies now reclaim the land by covering the area with topsoil. They grade the area to form a contoured landscape, then seed the area with native plants such as grasses and trees. Notice where reclamation has been started along the edge of this open-pit mine in Germany.

Oil

A hundred years ago crude oil was used to make kerosene, which is a fuel for lamps and stoves. Today crude oil is the world's most important source of energy.

In Alberta, the drilling for crude oil dates back to 1914. In that year, a miner named W.S. Heron noticed oil seeping from the ground on a farm near Turner Valley. He purchased the land and mining rights, and started drilling.

This discovery of oil near Turner Valley, and later at Leduc, Woodbend, and Redwater, has made Alberta into a major oil-producing area. Today, the province exports energy to the rest of Canada and the United States.

One problem with mining crude oil is knowing where to drill. Look at Figure 8.7 to see what a difference picking the right place to drill can make!

READING Check

Why is natural gas found on top of water and oil?

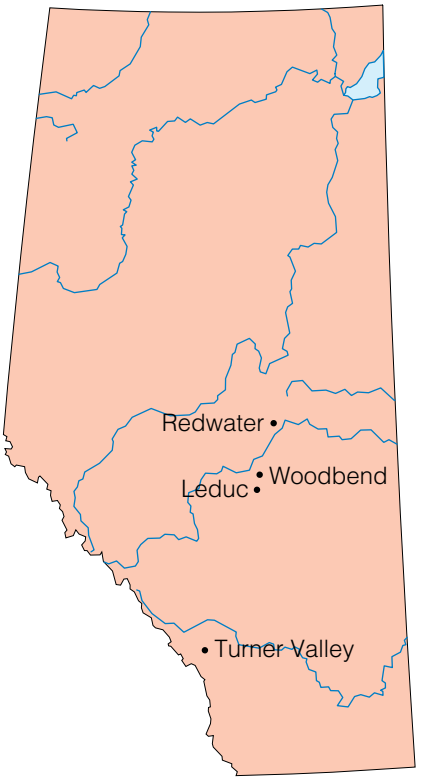


Figure 8.6 Alberta's Early Oil Deposits Research to find the areas of Alberta where oil is produced today. How would the loss of this industry affect Alberta's economy?

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2

Oil sands in the Fort McMurray area contain large reserves of petroleum. For more information on the oil sands and the technology used to extract oil from them, go to the above web site, then to Internet Connects, Unit B, Chapter 8, and then to Oil Sands.

Searching for Oil

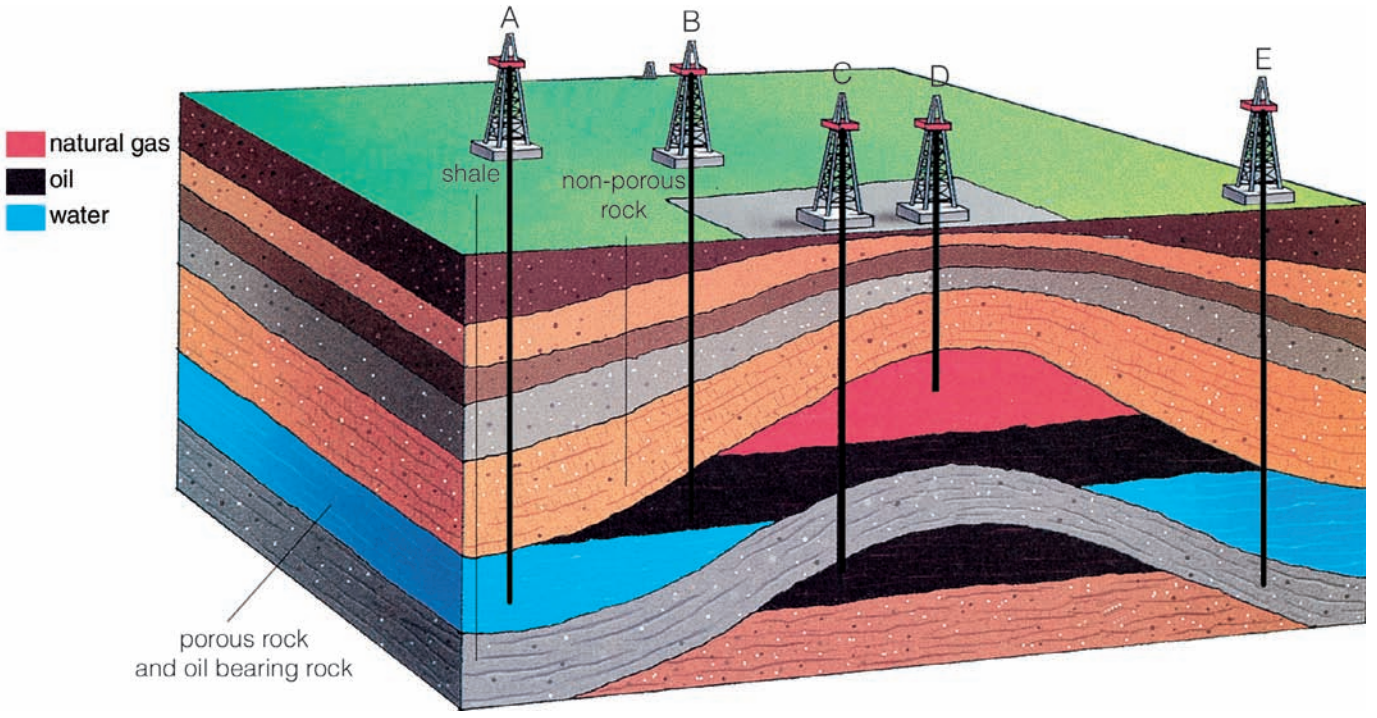


Figure 8.7 As oil developed, it mixed with water and sand. This mixture, along with bubbles of natural gas, seeped through porous layers of rock. Eventually, the mixture reached a layer of rock it could not pass through and was trapped.

The water, oil, and natural gas gathered under the non-porous layer of rock. Because natural gas is less dense than oil, it rose to the top.

The well at D pumps natural gas. What do the wells at A, B, C, and E get?

Diagrams such as Figure 8.7 may give the impression that oil forms in large, underground lakes. This is not correct. Oil is found in microscopic pores between the particles that make up rocks.

READING Check

Explain how geologists use a seismic survey.

Over time, changes in the Earth's crust caused great amounts of pressure that forced the tiny oil droplets into porous rock called **reservoir rock**. Further movements of the Earth's crust helped to trap oil and natural gas in sections of reservoir rock that are located between layers of impermeable rock. Figure 8.7 shows an oil-bearing structure that was formed as a result of these processes.

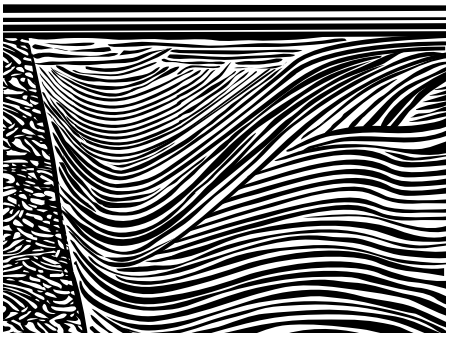


Figure 8.8 In this print out from a seismic survey, the different layers of rock are clearly visible.

Geologists use a number of technologies to determine the location of potential oil and natural gas reservoirs. One of the more common methods is the use of a **seismic survey**.

During a seismic survey, shock waves from compressed air guns, thumper trucks, or explosives are sent through the layers of the Earth's crust. The returning sound waves reflect off rock. They are detected by sensitive equipment and used to create images of the underground rock layers.

Geologists interpret these images and other data looking for structures that may contain oil and natural gas.

Drilling for Oil

Once seismic surveys identify likely places to find oil and gas, oil companies start to drill. When they hit reservoir rock with oil or gas, the fuel may come to the surface on its own.

As oil is removed from the reservoir, however, the pressure of the oil drops. In these cases, a pump is installed to bring the oil to the surface. In most cases, a **pump jack** is installed. In some areas, a **lift pump** may be used.

In the Find Out that follows, you will use a model to investigate the basic operation of a lift pump.

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2

For more information on how a land-based drilling rig operates, go to the above web site. Then go to Internet Connects, Unit B, Chapter 8, and then to Drilling Rigs.

READING Check

When is a pump used to bring oil to the surface?

DidYouKnow?

A garden hose with a hand-controlled nozzle can be compared to an oil well. The water in the hose is like the reservoir rock. Before the rock has been drilled into, the oil is under a lot of pressure.

Opening the nozzle is like drilling into the reservoir rock. In the case of the hose, water shoots out the nozzle. In the case of reservoir rock, oil may shoot into the air if it is under a lot of pressure. Otherwise, oil will be pumped to the surface.

Find Out ACTIVITY

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Model Lift Pump

The working component in an oil well is located deep underground. A simple lift pump can be used to demonstrate how this type of pump lifts oil hundreds of metres to the surface.

What You Need

model lift pump

4 litre plastic milk jug

4 litre bucket or sink

water

Safety Precautions

- Clean up the work area and wash your hands thoroughly at the end of this activity.

What To Do

1. Fill the plastic milk jug with tap water until it is about half-full.
2. Insert the intake tube of the lift pump into the water.
3. Arrange the outflow tube of the lift pump so that the water will go into a bucket or sink.
4. Slowly move the piston of the lift pump up and down.
5. Record your observations. Pay particular attention to what happens to the water and the valves each time the piston completes one cycle.

What Did You Find Out?

1. Draw a sketch of the lift pump when the piston is moving up. Use arrows to show the flow of water and what happens to the two valves during this phase of the operation.
2. Draw a similar sketch showing the lift pump when the piston is moving down. Use arrows to show the flow of water and what happens to the two valves during this phase of the operation.
3. Use a flow chart or other graphic organizer to summarize the operation of a lift pump.

Find Out ACTIVITY

Distilling a Soft Drink

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

What You Need

250 mL of cherry-flavoured cola
boiling chips
distillation apparatus
3 retort stands
2 retort stand rings
large tube clamp
heat pad
thermometer
Bunsen burner

Safety Precautions

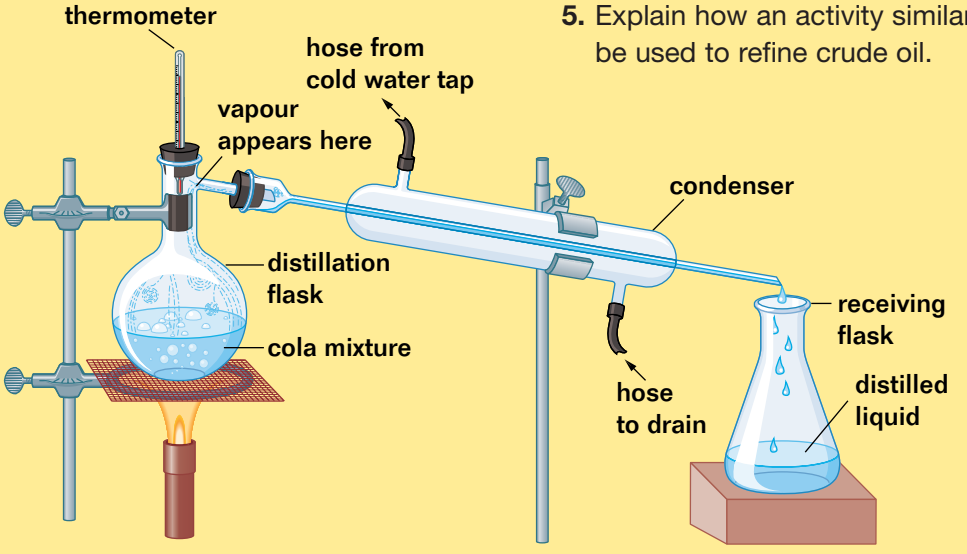
- If the soft drink bubbles and foams, remove it from the burner immediately
- Clean up the work area and wash your hands thoroughly at the end of the activity.

What to Do

1. Pour about 250 mL of the soft drink and two boiling chips into the boiling flask of the distillation apparatus.
2. Set up the distillation apparatus as shown in the diagram. The bulb of the thermometer should be completely in the liquid and not touching either the side or the bottom of the flask.
3. Connect one hose to the cold water tap. Run the other into the sink.
4. Gently heat the soft drink in the boiling flask.
5. As the liquid comes to a boil, note the odour of the vapour that comes from the condenser. Record your observations in your notebook.
6. Collect the liquid that runs out of the condenser. Note and record a description of the liquid.
7. Stop the distillation as soon as you have collected 1 or 2 mL of liquid.

What Did You Find Out?

1. Why is cold water used in the condenser?
2. How is the distilled liquid different from the original soft drink?
3. Water boils at 100°C. What was the temperature when this liquid boiled and condensed?
4. What is the liquid in the collection flask? What proof do you have for your answer?
5. Explain how an activity similar to this could be used to refine crude oil.



Refining Oil

Once crude oil is extracted from the ground, it is refined into many different products. This is done by a process called **distillation**. Distilling allows people to separate materials with a low boiling point from those with a higher boiling point. When oil is refined, it goes into a distillation system. Here, heavy lubricants such as motor oil and kerosene are separated from lighter liquids such as gasoline and naphtha.

In the Find Out activity, you worked with distillation to separate various materials.

Figure 8.9 Old Glory was the name of the discovery well drilled by Eugene Coste. This well was part of the Bow Island gas field, which was the first major discovery of gas in Alberta. The development of this field led to the first natural-gas pipelines to deliver gas to Alberta communities.

Natural Gas

In Figure 8.7 on page 140 you learned that natural gas is found underground in rock formations. You can see in the figure why it is often discovered in the same location as crude oil.

Until a few decades ago, when natural gas was found while drilling for oil it was simply burned off and wasted. Back then, natural gas was difficult to control. Oil was easier to control and transport.

Today there are pipelines across Canada to transport natural gas. In addition, trucks and ships have been developed that can transport it safely. As a result, the thermal potential energy of natural gas is used to heat houses and run industries.

Natural-gas pipelines run to towns and cities thousands of miles from the wells. These deliver natural gas directly to consumers, including homes, schools, and factories. Natural gas is a popular fuel because it causes less pollution than either coal or gasoline. In addition, it provides an immediate heat. This makes it excellent for cooking.

Like other fossil fuels, when natural gas is burned the stored energy is transformed to thermal energy for heating and cooking. The energy in natural gas can also be used to generate electric energy and provide thermal energy needed in some factories. Recently some vehicles have been developed that run on natural gas instead of gasoline.

Off the Wall

A Calgary company developed a device that can *smell* a gas leak from an airplane. Before this development, maintenance crews walked or drove along pipelines while inspecting for leaks. They used meters — and occasionally dogs — to sniff out the leak.

Check Your Understanding

1. Describe two ways in which coal is mined.
2. List three uses for each of the three fossil fuels.
3. Explain how the various components of crude oil can be separated.
4. Use a graphic organizer to show how oil, water, and natural gas arrange themselves under Earth's surface.
5. Explain how shock waves are used to find oil.
6. Draw a sketch showing how pumps are used to bring oil to the surface.

READING Check

How is natural gas used?

Key Terms

reservoir rock
seismic survey
pump jack
lift pump
distillation

8.3 Combustion

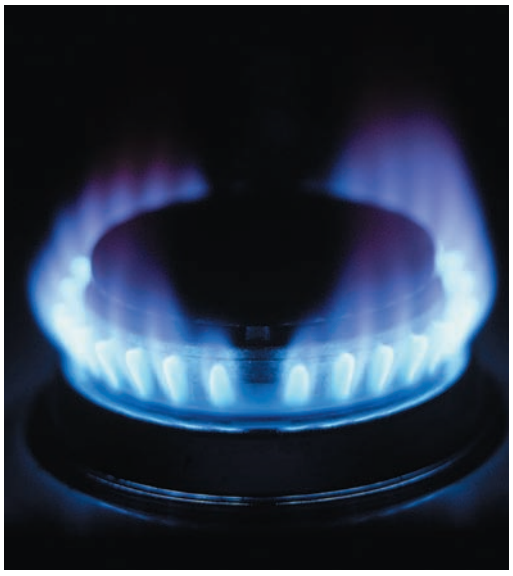


Figure 8.10 A blue flame is a sign of complete combustion. Smoky yellow flames indicate incomplete combustion. They are a sign that the flame is not getting enough oxygen.

Energy stored in fossil fuels is converted to thermal energy by **combustion** or burning. Combustion is a chemical reaction that takes place when a substance combines with oxygen. This process is discussed in detail in Unit A.

READING Check

What two products are formed when a fossil fuel completely combusts?

In the case of fossil fuels, combustion happens quickly. During the reaction, thermal energy is released.

Many people use propane when they want immediate heat. Propane is one of several gases that can be separated from natural gas. Combustion of this gas provides thermal energy to heat houses and cottages, as well as cook foods in restaurants and on barbecues. It is also used to run some motor vehicles.

The chemical symbol for propane is $C_3H_{8(g)}$. When propane burns completely, the equation for the reaction looks like this:

Combustion of Propane

propane gas	+	oxygen gas	→	carbon dioxide gas	+	water vapour
$C_3H_{8(g)}$	+	$5O_{2(g)}$	→	$3CO_{2(g)}$	+	$4H_2O_{(g)}$

DidYouKnow?

It is dangerous to use a gas barbecue or an unvented propane heater indoors. There is less oxygen available indoors than there is outside. When there is little oxygen, combustion is not complete and deadly carbon monoxide gas can be produced.

Like propane, all fossil fuels are made up of carbon and hydrogen. For this reason they are often know collectively as **hydrocarbons**. When fossil fuels burn completely in the presence of oxygen, they produce carbon dioxide gas and water vapour. Complete combustion ensures the maximum amount of thermal energy. It also ensures that carbon dioxide is produced.

If combustion is not complete, carbon monoxide will also be produced. Unlike carbon dioxide, this is a poisonous gas. Study Figure 8.8 to find out how you can tell whether a gas flame is producing carbon dioxide ($CO_{2(g)}$) or carbon monoxide ($CO_{(g)}$).

DESIGN & DO

INVESTIGATION 8–A

SKILLCHECK

Initiating and Planning

Performing and Recording

Analyzing and Interpreting

Communication and Teamwork

Examining Combustion

The paraffin used in wax candles is a hydrocarbon. Its chemical formula is $C_{25}H_{52(s)}$.

Challenge

Using a candle, develop an investigation to provide three pieces of evidence that a combustion reaction occurs as a candle burns.

Safety Precautions

- Be careful when working with open flames.
- Clean up the work area and wash your hands thoroughly at the end of the investigation.

Apparatus

2 tea candles
2 small 250 mL beakers
ring stand
wire mesh gauze
beaker tongs

Materials

tap water
2 ice cubes
matches

Design Criteria

A. Demonstrate the following:

- Oxygen is one of the reactants consumed in a combustion reaction.
- A hydrocarbon (paraffin) is consumed in a combustion reaction.
- Water vapour is produced in a combustion reaction.
- This combustion reaction is exothermic, meaning that it releases thermal energy.

B. Include safety precautions.

Plan and Construct

1. Review and list what goes into a combustion reaction and what the products are. (You may wish to review page 48 in Unit A.)
2. With your group, determine a procedure for your investigation.
3. Your procedure should include safety precautions for dealing with flames and liquid paraffin.
4. Get your teacher's approval before starting your investigation.
5. Carry out your investigation as outlined.
6. Record all of your observations in your notebook.

It is not difficult to show that a lighted candle gives off thermal energy. How can you use ice cubes to show that it also gives off water vapour? How could you show that soot (carbon particles) is also given off?

Evaluate

1. How does each of the following prove that a burning candle is a combustion reaction?
   (a) the candle flame
   (b) ice cubes
   (c) the outside of the glass beaker

Extend Your Skills

2. Describe a procedure you could use to demonstrate that oxygen is one of the reactants in a combustion reaction.

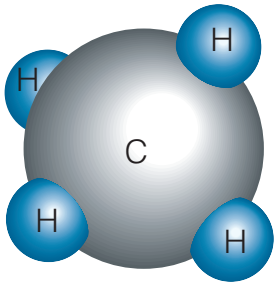


Figure 8.11 This artist's idea of a methane molecule shows four hydrogen atoms joined to a carbon atom. At the beginning of this section (on page 144), you saw the chemical formula for propane. Use this model to help you sketch a propane molecule.

Combustion and Cellular Respiration

Chapter 7 discusses how your body cells obtain energy through cellular respiration. Cellular respiration is a process similar to combustion. Study the two equations below to see how these two processes are similar.

Cellular Respiration

glucose	+	oxygen	→	carbon dioxide	+	water	+	energy
$C_6H_{12}O_{6(s)}$	+	$6O_{2(g)}$	→	$6CO_{2(g)}$	+	$6H_2O_{(l)}$	+	energy

Combustion of Methane

methane	+	oxygen	→	carbon dioxide	+	water	+	energy
$CH_{4(g)}$	+	$2O_{2(g)}$	→	$CO_{2(g)}$	+	$2H_2O_{(g)}$	+	energy

1. What "fuel" is burned in each case? **Hint:** What is the source of energy for a cell?
2. What gas does each source of energy react with?
3. What are the products of these reactions?

Your answer to questions 1 to 3 should show you that cellular respiration and the combustion of methane are similar chemical reactions. Both reactions produce a source of energy and use the gas oxygen. Carbon dioxide and water or water vapour are products of both.

A difference between these reactions is what happens to the energy. In combustion reactions, thermal energy is released. In cellular respiration, much of the energy is used to produce chemical energy for the body. Only a small amount is transformed into thermal energy. Another major difference is the rate at which the two reactions occur. Combustion happens rapidly, while respiration is slow and controlled.

READING Check

Compare cellular respiration and combustion.
How are they similar?
How do they differ?

Key Terms

combustion
hydrocarbons

Check Your Understanding

1. List three technologies that use combustion to convert the energy stored in fossil fuels into other forms of energy.
2. Copy the word and chemical equations for the combustion of propane ($C_3H_{8(g)}$). Label the input energy, converter, and output energy.
3. **(a)** Identify the two gases produced by both combustion and cellular respiration.
   (b) How else is cellular respiration similar to the combustion of a fossil fuel?

8.4 The Other Side of the Coin

At first the picture seems rosy. We need fossil fuels to keep us warm, to keep our homes and streets lighted, and to run our industries. Alberta's good supply of fossil fuels has a direct impact on the economy of the province.

READING Check

Why are fossil fuels said to be non-renewable?

Unfortunately, there is another side to this coin. Fossil fuels are **non-renewable**. Once used, they are gone. They cannot be re-used and will not form again within the foreseeable future. Just like fossil fuels from the past, plants and animals that die today will take hundreds of millions of years to become fossil fuels — if they ever do.

At the rate we are using these fuels today, we could run low in some fuels by the year 2010. By then, half of all easily recoverable oil will have been used. As global population and demand increases, more and more people compete for less and less oil, gas, and coal.

Figure 8.12 Fossil fuels take millions of years to accumulate. They are burned in minutes by internal combustion engines.As they combust, they create other problems. Which problem is evident in this photo of Vancouver?

Oil Spills

Fossil fuels can cause problems when they are transported. Study Figure 8.11 to see the kind of damage that occurs when oil tankers run aground or leak and spill millions of litres of crude oil into the ocean. Similar damage occurs when pipelines rupture or a gas well showers poisonous gas into the air.

In Investigation 8–B, you will look at how much oil we use and make predictions about the future.

READING Check

Name two problems we have when oil tankers run aground or leak oil.

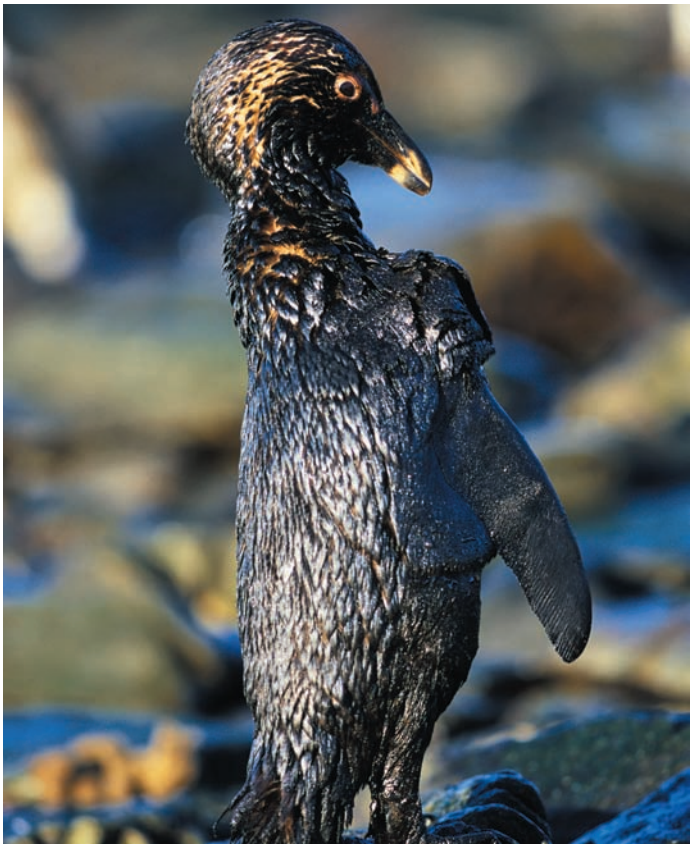


Figure 8.13 An oil spill puts marine life — fish, mammals, and birds — in danger. If they swallow the oil, it poisons them. If the oil covers their feathers or fur, it destroys natural insulation and waterproofing. The animals drown or freeze. This African penguin is covered with oil from a spill off the coast of South Africa. Some species of penguin are approaching extinction from this cause alone.

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

World Energy Consumption

Think About It

Energy consumption is measured in quadrillion kilojoules. One quadrillion is a 1 with 15 zeros after it. One kilojoule is about the same amount of energy as is released by a burning wooden match.

As world population increases, so does the demand for more energy from fossil fuels. Investigate the increase in our consumption of energy.

Year	Energy Consumption (quadrillion kilojoules)
1970	218
1975	256
1980	300
1985	328
1990	365
1995	386
2000	406
2005	463
2010	517
2015	577
2020	640

What to Do

1. Use the information in the chart to create a line graph showing the world's energy consumption between 1970 and 2000. Extend with a dotted line to show that the figures for 2000 to 2020 are projections.

Computer CONNECT

Use a computer spreadsheet program to illustrate the information in the table on a bar graph.

Analyze

1. Year after year, what happens to the consumption of energy around the world?
2. **(a)** Look at the figure for energy use in 1970. By what year was this consumption rate almost double?
   (b) About how long did it take to double the energy we use?
3. Extend your graph further into the future. Suppose we continue to expand our use of energy as we have in the past. When will we have doubled global energy consumption again from the year in 2(a)?
4. Some experts believe humans will exhaust supplies of fossil fuels in 100 years. List three things that can be done to ensure supplies last longer.

More Reasons to Reduce Fuel Consumption

Unit A discusses the fact that coal, natural gas, and gasoline often contain sulfur. The air contains 70 percent nitrogen. When these fossil fuels burn, sulfur from the fuel and nitrogen in the air combine with oxygen. Sulfur oxides and nitrogen oxides are released into the atmosphere. These oxides react with water vapour in the atmosphere to produce acid precipitation or **acid deposition**. Acid deposition includes rain, snow, and fog that contains sulfuric or nitric acid. It also includes acid-bearing particles that settle to Earth.

Acid deposition raises natural acidity in lakes and streams. When the acid levels get too high, fish cannot reproduce. Some lakes in northern Canada were once considered dead because acid deposition had killed the plants, algae, and fish that lived in them. Since the emissions from nearby industries have been cleaned with scrubbers, the lakes have begun to recover.

If acid deposition is harmful to wildlife, does it hurt humans too? Many scientists think it does.

READING Check

How does burning fossil fuels harm the environment?

Greenhouse Gas

Figure 8.14 The combustion of gasoline and diesel fuel releases unburned fuel, sulfur dioxide, nitrogen oxides, soot, and carbon dioxide into the atmosphere. This can result in smog, which is a combination of air pollution (smoke) and fog. Breathing air like this is bad for your health.

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2

Use the Internet to investigate how acid deposition, global climate change, and oil spills are three major environmental problems associated with the use of fossil fuels. Go to the above web site, then to Internet Connects, Unit B, Chapter 8, and then to Problems with Fossil Fuels.

Unit A discusses the greenhouse effect. The natural greenhouse effect is good because it traps thermal energy and makes Earth warm enough for living things. But many scientists think the burning of fossil fuels has resulted in an increase in greenhouse gases. This higher level of greenhouse gases is trapping more heat inside Earth's atmosphere. The majority of scientists believe this will cause changes to our climate.

READING Check

Why is global climate change a concern?

They predict that some places will get much warmer, while others will get cooler. Scientists call this phenomenon **global climate change**.

Aboriginal groups in northern Canada also say that the climate is changing. They report that winters are getting warmer and that the permafrost is melting. Scientists say that increasing temperatures and decreasing precipitation may lead to new deserts. In addition, they have found that Earth's ice caps and glaciers are melting faster today than they were a few decades ago. Melted glaciers will raise ocean levels and flood low-lying areas.

DidYouKnow?

Particles from fuel emissions, as well as nuclear wastes and PCBs, are being found in glaciers around the world, including those in the Rocky Mountains of Alberta.

Check Your Understanding

1. List three risks associated with our use of fossil fuels.
2. Use a labelled diagram or flowchart to explain how an increase in greenhouse gas might make Earth warmer.

Key Terms

non-renewable
acid deposition
global climate change

CHAPTER

8 Review

Key Terms

fossil fuels
coal
natural gas
crude oil
petroleum
reservoir rock
seismic survey
pump jack
lift pump
distillation
combustion
hydrocarbons
non-renewable
acid deposition
global climate change

Reviewing Key Terms

If you need to review, the section numbers show where these terms were introduced.

1. In your notebook, write the correct key term or terms to complete each of the following sentences. Each key term is used only once.

(a) Coal, oil, and natural gas are examples of _____ _____ . (8.1)

(b) _____ _____ is a fossil fuel that can be found in the same rock formations as oil. (8.1)

(c) _____ is a fossil fuel found in thick beds or seams. (8.1)

(d) The process of _____ can be used to separate the components of a mixture. (8.2)

(e) The _____ of fossil fuels is a common way to convert the energy in these compounds into other forms of energy. (8.3)

(f) _____ _____ is often found underground between a layer of water and natural gas.

(g) Because they consist of carbon and hydrogen, fossil fuels are called _____ . (8.3)

(h) Once they are gone, they are gone. Fossil fuels are _____ . (8.4)

(i) One reason to be concerned about burning fossil fuels is that this combustion may contribute to _____ _____ .

Understanding Key Ideas

Section numbers are provided if you need to review.

2. Describe briefly how one of the fossil fuels — coal, oil, or natural gas — was formed. (8.1)

3. Describe conditions in Alberta millions of years ago that led to the formation of fossil fuels. (CO)

4. How was the coal industry important to the early European settlers in Alberta? (8.2)

5. List four reasons why oil is an important resource. (8.2)

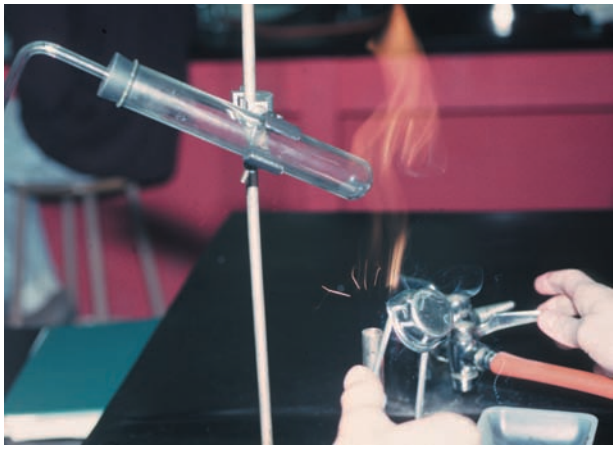
6. Explain why crude oil is considered to be a non-renewable source of energy. (8.4)

7. List two benefits associated with the fossil fuel industry. (8.4)

Developing Skills

8. Explain how acid deposition forms. (8.4)

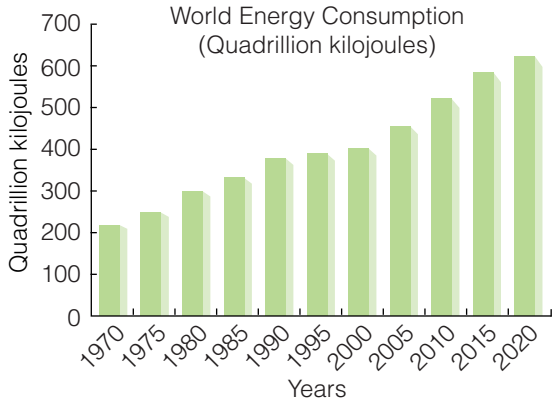
9. List three observations that would lead you to infer that a Bunsen burner flame is an example of a combustion reaction. (8.3)



10. Use information in the bar graph to explain the following: (8.4)

(a) What is happening to world energy consumption?

(b) Approximately how many more kilojoules of energy do experts think will be used in 2020 than were used in 1970?



11. Develop a series of cartoons or sketches showing how reservoir rock is identified and drilled.

Problem Solving/Applying

12. What type of reaction is shown by the following chemical equation? (8.3)

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)} + \text{energy}$$

methane gas + oxygen → carbon dioxide + water vapour + energy

13. Study the following chemical equations. Note three comparisons of the combustion of propane with cellular respiration. (8.3)

Combustion of Propane

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)} + \text{energy}$$

propane gas + oxygen → carbon dioxide + water vapour + energy

Cellular Respiration

$$C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)} + \text{energy}$$

glucose + oxygen → carbon dioxide + water + energy

Critical Thinking

14. Write a 30-second radio commercial, or develop a poster or brochure, informing your audience of a problem associated with fossil fuels and the environment. (8.4)

Pause & Reflect

1. Earth's reservoir of fossil fuels, including natural gas, will not last forever. In addition, burning fossil fuels releases carbon dioxide (a greenhouse gas) and other pollutants into the atmosphere. On the other hand, alternative sources of energy, such as solar panels and wind power, are expensive. They may also be less reliable than using fossil fuels. What do you think? What is the most responsible way to heat our homes, get around, and run businesses?

2. Check your answers to the Getting Ready questions on page 134. How has your thinking changed? How would you answers those questions now that you have investigated the topics in this chapter?

unit B PROJECT

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Designing an Energy Transformation Device

Energy is a concept you use every day. You may say that eating a plate of spaghetti gives you energy or that an Olympic athlete has a lot of energy. You may hear your parents comment on how much energy puppies have as they play.

Ancient Greeks used the term *energos* to refer to energy. To them, energy meant "active." Today, scientists define energy as the ability to cause change. Energy can change the temperature, shape, speed, or direction of an object.

Unit B describes and investigates energy transformations. It discusses the three basic components of an energy transformation: input energy, a converter, and output energy. Investigations in the unit show how the useful output energy is always less than the input energy. What happens to most of the waste energy?

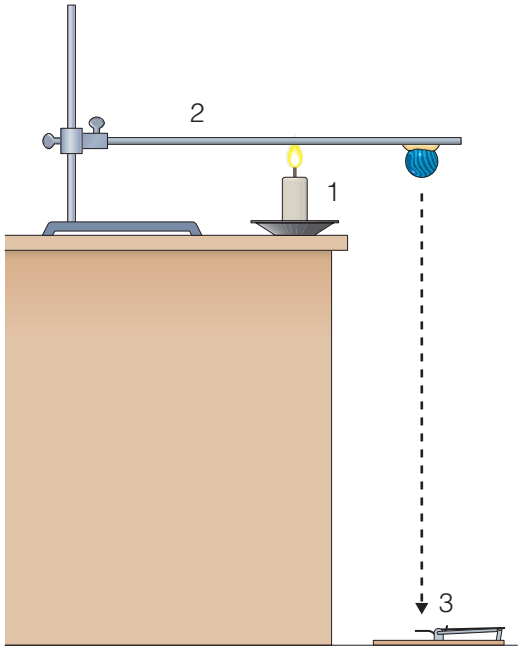
In this activity you will design a device that demonstrates at least two energy conversions. The device does not have to have a purpose — but it would be nice if it did. Study the illustration to see one person's idea for this activity. It may give you some ideas.

Challenge

Using the knowledge you have gained in this unit, construct a device that demonstrates at least two energy transformations.

Safety Precautions

- Consult with your teacher before taking steps to use a corrosive chemical.
- Plan with your teacher if your group plans to use a power tool.
- Do not use power tools, unless under the supervision of a shops teacher.
- Clean up the work area and wash your hands thoroughly at the end of each work period.



A student designed the energy transforming device shown above.

This device displays a number of energy transformation systems.

System 1 The chemical energy in the candle is transformed into thermal energy when the candle is burning.

System 2 The thermal energy of the candle heats the thin metal rod and melts the wax holding the marble. The potential energy of the marble is transformed into kinetic energy when the marble starts to fall.

System 3 The spring of the mousetrap has potential energy. The kinetic energy of the falling marble releases the mousetrap's spring. The potential energy of the spring is transformed into kinetic and sound energy when the mousetrap snaps shut.

Materials

shoe box	glue
construction materials	batteries
tools	1.5 volt light bulbs
cardboard	toy motors
scrap wood	mousetrap
wheels	elastic bands
tape	other materials that you may require

Design Criteria

A. Working with a partner, brainstorm ideas for different devices that show two energy transformations.

B. Sketch a detailed design of a device that demonstrates two energy transformations. Your design should address these points:
- The device should be able to do some work.
- The device should fit into a space about the size of a shoe box.
- The device should be made with readily available materials. Your teacher may provide some of the materials for you. You and your partner will have to supply the others.

C. Use what you know about energy conservation to try to reduce waste energy.

Plan and Construct

1. As a class, list the energy transformation systems you have investigated in this unit.
2. From this list, identify two systems that you and your partner can put together in a single device.
3. Complete a detailed sketch of your energy transformation device.
4. As you plan your device, consider:

   (a) What kinds of materials can you use?

   (b) Where can you improve the efficiency of the energy transformations? For example, you might plan to reduce friction.

5. Develop a list of safety precautions for working with the materials you will use to build the device.
6. Have your teacher review and okay your plans.
7. Construct your device.
8. Test a prototype of your device. Troubleshoot problems as they arise.

Evaluate

1. Explain how you modified your device to improve the efficiency of the energy conversions.
2. Complete a detailed sketch of your final device. How has it changed from your original blueprint?
3. On your diagram in question 2, identify and describe the two energy transformation systems that you built into your design. Clearly identify the input, converter, and output in both systems.
4. How could you add one more energy transformation system to your device?

Extension

5. Once inventors have built a machine, they then consider how the machine could be improved. How might your machine be improved so it could do more work?